MEASURING AND MODELLING OF THE DIRECTIONAL WAVE SPECTRUM IN SWADE

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LONG-TERM GOAL

To understand the physics of the evolution of surface waves in the open ocean and their influence on air-sea interaction and mixed layer dynamics.

SCIENTIFIC OBJECTIVES

In this study I examined the response of the wave field under different environmental and meteorological conditions and made simulations of the evolution of the directional wave spectrum with the WAM ocean wave model on a basin, regional and fine mesh scale. With the buoy measurements I examined the source function balance with the WAM model and measured data over the SWADE array. An extensive data of wind stress measurements were used to establish a relationship between wind stress and the directional wave spectrum. Finally, using buoy observations and modelling results, I also examined the importance of wave-current interaction.

APPROACH

The modelling team (Hasselmann (MPI), Jensen (CERC) and Graber) has examined the current WAM model physics (deep and shallow water propagation, source and sink terms, wave-current interaction) with wind fields from the primary SWADE "intensive observation periods". Using high-resolution, manually generated wind fields (by V. Cardone, Oceanweather) for each of the three IOPs, which minimize especially the induced uncertainties in the wind forcing, we examined the WAM model response and sensitivity to temporal and spatial resolutions of wind fields, wave-current interaction and shallow water processes and compared them to the observed wave fields.

In collaboration with Donelan and Drennan, we used an extensive data set of the directional wave spectrum and air-sea fluxes from measurements on the directional wave buoys deployed in SWADE and later during the two High Resolution Remote Sensing Experiments (HIRES) to study the influence of the non-stationary conditions of the wave field on the marine surface stresses.

Ambient noise data measured with a WOTAN sensor on MET-3 are used to explore its utility as a remote wind sensor and dissipation rate estimator. The noise sound spectrum levels are converted to wind speed estimates by using the FASINEX algorithm.

WORK COMPLETED

1. Wind stress from K-Gill anemometers have been synchronized with directional wave spectra for further analysis.

2. The entire SWADE wave data set has been decomposed into individual wave components using the partitioning scheme developed by J. Hanson (JHU/APL).

3. Evaluation of various microwave instruments with the SWADE discus buoys during the IOP-3 has been completed (in collaboration with S. and K. Hasselmann).

SRESULT

Determining a parameterization of the sea surface drag coefficient in terms of readily measured quantities such as mean wind speed and atmospheric stability has not been adequate to reduce the considerable scatter found between experiments. Few experiments have also measured simultaneously the spectral properties of waves to examine the role waves on the surface drag. From the SWADE measurements we found that much of the scatter in the drag coefficient is due to the presence of swell or nonstationary conditions.

Estimating wave growth and directional relaxation characteristics from directional wave spectra is only meaningful when the spectra are decomposed into individual wave trains. From this analysis it becomes readily apparent which components of the wave field respond directly to the wind forcing (wave growth) and sudden changes in the wind direction (directional relaxation).

IMPACT/APPLICATION

The overall SWADE modelling effort has led to an improved surface wave modelling capability within the Navy and Army. Global data bases of modelled wave heights are assembled to assess trends in wave climatology, but also begin to provide input of sea state information to other models describing ocean dynamics. High-resolution applications to marginal seas and coastal embayments have been successfully implemented and are continuously tested and improved using more recent data sets from DUCK94 or the very high-resolution wind fields produced FNMOC coupled ocean-atmosphere model COAMPS. The recent interest in littoral oriented missions has led to a focused interest in understanding the physics and dynamics of shoaling waves, especially the wind input and dissipation terms.

TRANSITIONS

I continue to collaborate with CERC (R.E. Jensen) on setting up high-resolution wave forecasting modules for NAVOCEANO (A. Johnson and P. Ferrar) in several specific regions. These modules are being tested globally by validating the prediction with altimeter-based wave heights. These modules are the result of our modelling effort carried out in SWADE and are integrated into the global wave forecasting system at FNMOC.

I continue to discuss with NRL-Stennis (T. Keen) on how to integrate modelling components for surface waves, sediment transport, coastal circulation, wind field into a coastal model system in order to evaluate the state-of-the-art capabilities and deficiencies of such a system.

RELATED PROJECTS

Many technical and modelling efforts developed and tested in SWADE were successfully used in HIRES and DUCK94. The nested SWADE model has also been transported to the Pacific to test the validity of ERS-1 derived wind fields on two northern Pacific storms. With R. Jensen (CERC) and S. Chang (FNMOC) the SWADE model predictions will be tested with the COAMPS wind fields for the IOP-1 storm.

We deployed the WOTAN during the NSCAT validation experiment in the Gulf of Mexico with the ONR-funded air-sea interaction spar (ASIS) buoy. This buoy measures high-resolution directional wave spectra with a nested wave-gauge array as well as direct wind stress and flux profile data of wind and dry/wet air temperature. The combined suite of measurements will allow improving the ambient noise algorithms (SWADE and FASINEX) and also examining the influence of wave breaking.